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EVALUATION OF MECHANICAL PROPERTIES OF STEEL FIBRE REINFORCED CONCRETE WITH OPC43 AND 53 GRADES

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ABSTRACT

The various previous research studies have proved that plain concrete possesses low tensile strength, low resistance to cracking and limited ductility. The addition of fibers enhanced various characteristics of concrete, it has also been proved that the use of steel fibres improved the strength of concrete. Steel fibre is considered to be the most popular type of fibre used as concrete reinforcement. The basic purpose of using steel fibre is to prevent or control plastic and drying shrinkage. Steel fibres also increase flexural strength, ductility, durability and reduce fatigue. The present study focuses on the mechanical properties of steel fibre reinforced concrete. (SFRC) prepared with two grades of OPC 43 and 53. As per IS 10262-2009 M40 grade of concrete with super plasticizer at water cement ratio 0.40 is considered for the study. The steel fibre with varying percentage of composition i.e. 1%, 2 %, 3%, 4%, 5% and 6% is added by weight of cement. The strengths and durability of SFRC are studied and compared with the controlled concrete.

KEYWORDS: Compressive Strength, Split Tensile Strength, Flexural Strength & Durability

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INTRODUCTION

Concrete is the most widely used versatile construction material possessing many desirable properties like high compressive strength and durability under normal environmental conditions. At the same time, concrete has some disadvantages. Plain concrete has very low tensile strength and limited ductility. Plain concrete does not offer much resistance to cracking. The development of micro cracks limits its tensile strength. Initially, these unsightly cracks do not harm too much extent, but on propagation the magnitude of loss and the severity of damage will be more. The concrete with brittle nature, low tensile strength is more susceptible to fracture. These difficulties can be overcome by reinforcing concrete with fibres. The fibre reinforced concrete has been considered as a boon in construction since it is a better option by which the cracks can be effectively arrested. Fibre reinforced concrete is a composite material consisting of cement motor with random distribution of small fibres with high tensile strength. The presence of uniformly distributed fibres increases the cracking strength of concrete and these fibers effectively arrest the cracks in concrete. It is true that development of cracks in concrete without fibres is inevitable. It was identified that the addition of small closely spaced and uniformly dispersed fibres would successfully prevent or arrest these cracks. The presence of these fibres certainly improve static and dynamic properties of concrete. Steel fibre has been proved as one of the best fibres because the use of steel fibres makes significant improvements in compressive strength, flexural strength, impact and fatigue strengths of concrete. In this experiment hooked fibres at both ends with aspect ratio 50 are used.

MATERIALS USED

Cement

OPC 53 grade and 43 grade of Cement have been used and are conforming to IS 12269:2013. The physical properties of the specimen cement are stated below.

Table 1: Properties of 53 and 43 Grade Cement

Properties of 53 Grade Cement		Properties of 43 Grade Cement	
Specific Gravity	3.10	Specific Gravity	3.15
Normal Consistency	26%	Normal Consistency	27%
Fineness	8%	Fineness	8%

Coarse Aggregate

Crushed angular/cubical aggregate of maximum 20mm has been used. The physical properties are stated below

Table 2: Properties of Coarse Aggregate

Properties of Coarse Aggregate	
Specific Gravity	2.7
Crushing Value	12.42%
Abrasion Value	14.5%
Impact Value	11.2%

Fine Aggregate

Clean and dry river sand available locally and conforming to grading zone 2 of IS: 383-1970 has been used. Sand passing through IS 4.75mm sieve was used for casting all the specimens. The physical properties are stated below.

Table 3: Properties of Fine Aggregate

Properties of Fine Aggregate	
Specific Gravity	2.4
Water Absorption	0.8%
Bulking of sand	11.9%

Water

Fresh and portable drinking water locally available was used for curing and casting of specimens. Because the role and influence of water is very much imparted in strength and durability characteristics of concrete

Admixture

GLENIUM 110M complies with ASTM C494 has been used and also it is compatible with all Portland cements that meet recognized international standards.

Steel Fibre

Table 4: Properties of Steel Fibre

Properties of Alkali Resistance Steel Fibre	
Diameter	0.75 mm
Length of fiber	60 mm
Appearance	Bright in clean wire
Average aspect ratio	80
Deformation	Hooked at both ends

Table 4: Contd.,	
Tensile strength	1050 MPa
Modulus of Elasticity	200 GPa
Specific Gravity	7.8

Test Specimens

Test specimens were cast with the following dimensions using M40grade of concrete with 43 grade and 53 grade of cement and tested as per IS: 516 and 1199.

150×150×150 mm Cubes, 100×100×500 mm Beams and 150×300 mm Cylinders

EXPERIMENTAL PROCEDURE

Compressive Strength Test

The compressive strength test was conducted on cube specimens with standard dimensions 150×150×150 mm. Substantial care has been exercised the largest nominal size of the aggregate not to exceed 20mm. Hook tain Steel fibres were used with aspect ratio 50, having length 35mm with diameter 0.70. Fibre was added at the percentages of 1%, 2%, 3%, 4%, 5% and 6% by weight of cement. The cubes were cured for a period of 28 days. The test specimens were tested as per IS 516-1959 using a calibrated compression testing machine of 2000KN capacity. The compression load is noted at a point where the specimen was failed. The compressive strength of the specimen has been calculated with the following formula

$f_c = (P/A)\ N/mm^2$

Where, P = Load at which the specimen fails in Newton (N), A = Area over which the load is applied in mm^2 and f_c = Compressive Stress in N/mm^2

Flexural Strength

The flexural strength of the test specimens is determined by loading a plain concrete beam specimen at one-third span of the beam. The beams were cast with the standard size of 100×100×500 mm. The test procedure was carefully exercised that the load is partitioned between the two stacking rollers, and all rollers might be mounted in such a way, to the point that the load is connected pivotally and without subjecting the specimen to any torsional twisting. Hook tain Steel fibres were used with aspect ratio 50, having length 35mm with diameter 0.70. Fibre was added at the percentages of 1%, 2%, 3%, 4%, 5% and 6% by weight of cement. The beams were cured for a period of 28 days and tested. The failure load is noted at a point where the specimen was failed. The flexural strength of the specimen has been calculated with the following formula

Flexural Strength (Mpa) = PL/bd^2

Where P=Failure Load, L=centre to centre distance=500mm, b=width of the specimen=100mm and d=Depth of the specimen=100mm

Split Tensile Strength Test

The Split tensile strength of cylindrical specimens of standard size 150 mm × 300 mm has been determined. Hook tain Steel fibres were used with aspect ratio 50, having length 35mm with diameter 0.70. Fibre was added at the percentages of 1%, 2%, 3%, 4%, 5% and 6% by weight of cement. The specimens were cast and cured for a period of 28

days. Then the specimens were tested as per IS: 516-1959 using a calibrated compression testing machine of 2000KN capacity. The tensile strength of the specimen has been calculated with the following formula

$f_t = (2P/\pi dl)$ N/mm^2

Where,

P = Maximum load in N applied to the specimen, d = Measured length in cm of the specimen

l = Measured diameter in cm of the specimen and f_t = Tensile strength N/mm^2

Durability Test

The durability of the concrete is determined by calculating the loss of weight of test specimen when they were exposed to concentrated sulphuric acid (H_2SO_4). The solution was prepared by mixing 5%of Conc. H_2SO_4 with one litre of distilled water as per ASTM G20-8. After normal curing for a period of 28 days, then the cubes were taken out and weights of the cubes were noted. Then a weighted cube was immersed in the prepared sulphuric acid for 56 days. After curing period the cubes were taken out from the acid and weight of cubes was noted. The loss of weight has been calculated by the following relation.

Weight loss = (Weight of cube after Normal Curing) – (Weight of cube after exposed to Conc. H_2SO_4 Solution)

MIX PROPORTION

As per IS 10262-2009 designed by M40 grade of Concrete and Cem-FIL Anti-Crack HD as a Super plasticizer and water cement ratio 0.40.

Table 5: Mix Proportion

Material	Quantity (kg/m^3)	Proportion
Cement	405	1.00
Fine aggregate	607	1.50
Coarse aggregate	1215	3.00
Water	162	0.40
Super plasticizer (Cem-FIL Anti-Crack HD)	4.05	0.01

RESULTS ANALYSIS

Compressive strength of M40 with 53-grade and 43-grade cement

Table 6: Compressive Strength of 28 Days

Type of Concrete	Age of Concrete (53-Grade Cement)	Age of Concrete (43-Grade Cement)
	28 days	28 days
Control concrete	45.00	38.00
1% steel fibre	53.64	41.00
2% steel fibre	54.00	44.10
3% steel fibre	57.20	47.10
4% steel fibre	55.40	43.00
5% steel fibre	53.40	42.60
6% steel fibre	52.00	40.00

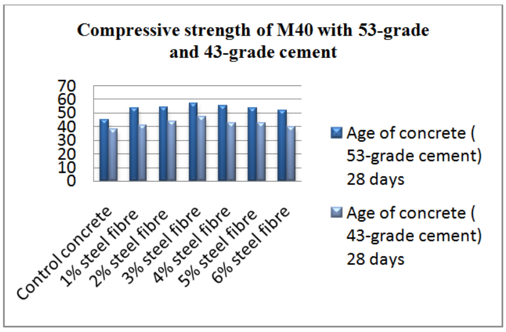

Figure 1: Compressive Strength of M40 with 53-Grade and 43-Grade Cement

Flexural Strength

Flexural strength of M40 with 53-grade and 43-grade cement.

Table 7: Flexural Strength of 28 Days

Type of Concrete	Age of Concrete (53-Grade Cement) 28 Days	Age of Concrete (43-Grade Cement) 28 Days
Control concrete	6.8	4.00
1% steel fibre	8.50	5.80
2% steel fibre	9.40	6.60
3% steel fibre	10.10	7.50
4% steel fibre	9.60	6.40
5% steel fibre	8.50	5.20
6% steel fibre	8.00	5.00

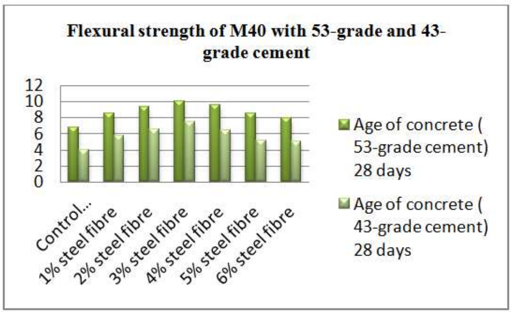

Figure 2: Flexural Strength of M40 with 53-Grade and 43-Grade Cement

Split Tensile Strength

Split Tensile Strength of M40 with 53-grade and 43-grade cement

Table 8: Split Tensile Strength of 28 Days

Type of Concrete	Age of Concrete (53-Grade Cement) 28 Days	Age of Concrete (43-Grade Cement) 28 Days
Control concrete	4.00	2.90
1% steel fibre	4.40	3.20
2% steel fibre	4.60	3.40
3% steel fibre	5.10	3.80
4% steel fibre	4.80	3.50

Table 8: Contd.,		
5% steel fibre	4.60	3.10
6% steel fibre	4.20	2.90

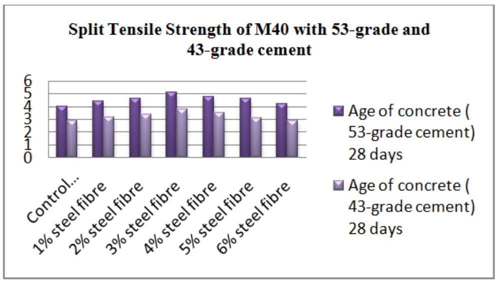

Figure 3: Split Tensile Strength of M40 with 53-Grade and 43-Grade Cement

Durability

Durability of M40 with 53-grade and 43-grade cement.

Table 9: Weight Loss of Specimens after 56 Days

Type of Concrete	Age of Concrete (53-Grade Cement) 56 Days	Age of Concrete (43-Grade Cement) 56 Days
Control concrete	0.39	0.63
1% steel fibre	0.41	0.64
2% steel fibre	0.43	0.66
3% steel fibre	0.45	0.68
4% steel fibre	0.46	0.69
5% steel fibre	0.47	0.69
6% steel fibre	0.49	0.70

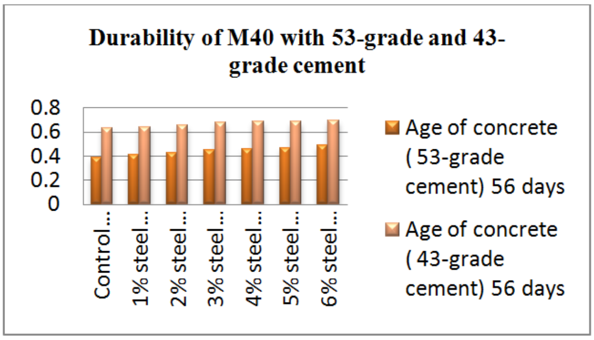

Figure 4: Durability of M40 with 53-Grade and 43-Grade Cement

CONCLUSIONS

- From the research, it has been identified that the maximum compressive strength is attained with the addition of 3% fibre in 53-grade of OPC it was found to be 57.20 KN/mm^2 and with 43-grade of OPC it was found to be 47.10 KN/mm^2 then the trend started decreasing with the addition of fibre with both the grades of concrete.
- From the research, it has been identified that the maximum flexural strength is attained with addition of 3% fibre with 53-grade of OPC it was found to be 10.10 KN/mm^2 and with 43-grade of OPC it was found to be 7.50

KN/mm^2 then the trend started decreasing with addition of fibre with both the grades of concrete

- From the research, it has been identified that the maximum Split Tensile Strength is attained with addition of 3% fibre with 53-grade of OPC it was found to be 5.10 KN/mm^2 and with 43-grade of OPC it was found to be 3.80 KN/mm^2 then the trend started decreasing with addition of fibre with both the grades of concrete
- The weight loss has been increased with the increase of fibre content due to the acid attack.

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